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PRIVATIZING GOVERNMENT OPERATIONS — A SYSTEMS APPROACH

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Abstract. The Hanford Area is a U.S. Department of Energy (DOE) reservation in Southeastern Washington, where the primary mission for nearly fifty years was production of nuclear weapons materials. It is now the nation's largest superfund site and its sole mission is environmental remediation of the mixed wastes generated during plutonium production. A large fraction of these wastes are stored in 177 underground tanks and are the subject of the DOE's Tank Waste Remediation System (TWRS) Program. Since its inception the TWRS Program has been managed by a Maintenance and Operations (M&O) contractor.

The DOE is now considering the privatization of a portion of this program and has recently issued a Request for Proposals (RFP) seeking new, qualified, private vendors. Successful bidders will be expected to build waste processing facilities with their own financial resources and to recover their costs by charging fixed prices for the various products delivered to the DOE. Because the TWRS Program is such a large, complex, and expensive undertaking, the privatization initiative will be conducted in two phases: a small proof-of-concept phase, followed by full-scale production. A primary objective of the proof-of-concept phase is to test this new contracting approach by determining the interest of private companies and demonstrating their technical capabilities.

The key to a successful demonstration is establishing the right set of requirements to be satisfied by the private vendors. These requirements must be consistent with the existing requirements set developed over the past three years by the M&O contractor. This paper presents the results of a systems engineering effort that was conducted in support of the RFP preparation and had to be coordinated with an ongoing program. Much of the effort was focused on the specification of new proof-of-concept requirements that are directly traceable to corresponding requirements in the M&O's RDD-100® database. A new functions and requirements database was created for this first privatization phase using CORE®, a systems engineering support tool, produced by Vitech Corporation.

Introduction

High-level radioactive waste (HLW) has been stored in large underground storage tanks at the Hanford Site since 1944. Approximately 60 million gallons of waste are currently being stored in 177 tanks. In 1992, the Tank Waste Remediation System (TWRS) Program was established to manage, process, and dispose of these wastes in a safe, environmentally-sound, and cost-effective manner. Soon thereafter, the TWRS Program began implementing a systems engineering approach which resulted in a functional decomposition for the TWRS baseline (Figure 1), a substantial database of requirements pertaining to these functions, and a preferred set of strategies and chemical processes for satisfying them. This baseline concept called for the TWRS maintenance and operations contractor (M&O) to design, construct, and operate full-scale, centralized facilities to accomplish the TWRS mission. Requirements applicable to the TWRS Program were extracted from federal laws, the Code of Federal Regulations, DOE Orders, the Washington State Administrative Code, M&O procedures, and many other documents. These TWRS requirements have been categorized according to whether the requirement is imposed by some external regulatory authority (constraint) or self-imposed by the DOE or the M&O contractor (performance requirement), and whether it applies to the function itself (functional requirement) or one of its inputs or outputs (interface requirement). Table 1 illustrates examples of each type of requirement pertaining to the "Immobilize HLW/TRU Waste" function.

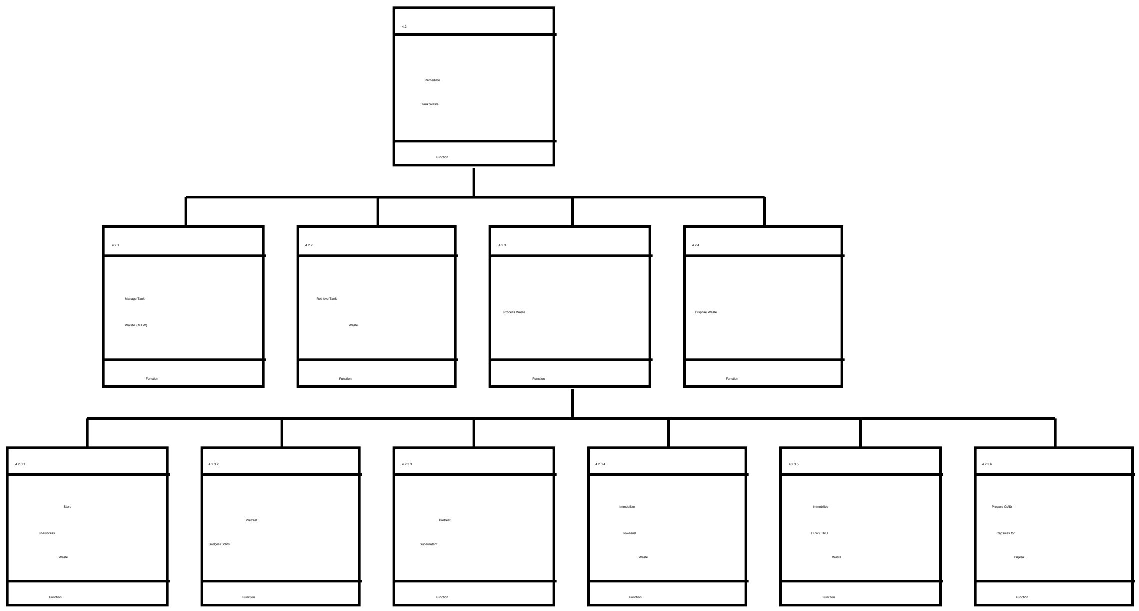

Figure1. TWRS Functional Hierarchy (Partial)

Typical CORE Function Description Table

4.2.3.5 - Immobilize HLW / TRU Waste: Receive and immobilize pretreated HLW and TRU waste, solidified cesium and technetium containers (from Interim Store Solidified Waste, 4.2.4.1), seal the immobilized waste into primary containers, decontaminate the container outer surfaces, and test the integrity of the sealed containers. Load the immobilized HLW/TRU waste in transport mechanism for shipment to the interim storage facility. The transport mechanism is provided by the Interim Store Solidified Waste function (4.2.4.1). This function also includes treatment/preparation of liquid, gaseous, and solid wastes generated during immobilization of HLW/TRU.

Tank waste immobilization will begin when the immobilization facility is authorized to begin hot operations and will continue until all of the immobilized HLW/TRU has been transferred to interim storage.

Inputs:

Pretreated HLW for Immobilization

Outputs:

IHLW for Storage

Traced From:

Performance Requirement: HLW Vitrification Production Capacity

The HLW vitrification production capacity shall be nominal 8 MT/day glass. The design basis shall be 20 MT/day. Basis: The TWRS Reference Flowsheet, WHC-SD-WM-TI-613, is based on an enhanced sludge wash process which produces approximately 12,000 MT of sludge which is immobilized in glass at a 45% waste oxide loading. On this basis, a vitrification facility with a nominal 8 MT/day throughput and a total operating efficiency of 60% will have adequate capacity to complete its mission by 2024. This time period includes one year of startup and 14 years of nominal capacity operation. These conditions would produce 23,800 MT of HLW glass in about 7,100 TWRS reference canisters (1.26 cubic meters). The 14 year operating period is based on a parametric optimization study of operating versus capital costs which showed a 5 to 15 year operating period providing a minimum life cycle cost.

Typical CORE Function Description Table
Proof-of-Concept Requirement: Test Phase I - Throughput - HLW The phase 1 processing demonstration capacity for HLW immobilization is 1 MT/day of HLW glass. This capacity translates to processing 190 MT of waste oxides, excluding Na and Si, within 4 years of hot start up of the facility. Note: Assumed operating efficiency of 30% total operating efficiency in the first year of operation and 60% thereafter.

Table 1. Examples of TWRS Requirements for the Immobilize HLW/TRU Waste Function.

TWRS Privatization

Since its inception, the contracting strategy for the TWRS Program has been for an M&O contractor to operate a government-owned, contractor-operated (GOCO) facility with a cost-plus-award-fee contract. Under this arrangement, the Department of Energy (DOE) bears the full responsibility, accountability, and liability for development work, design, permitting, construction, and operation of the facilities. Over the past year, the Department has determined that privatizing portions of the TWRS Program may be preferable to the GOCO contracting strategy. Energy Secretary Hazel O'Leary decided in September, 1995 to pursue privatization and announced that a request for proposal would be issued in February, 1996 with work by private firms expected to begin by September.

In pursuing the concept of privatizing TWRS, the Department is proposing to change its contracting approach to the purchase of products from a contractor-owned, contractor-operated (COCO) facility under a fixed-price type of contract. The underlying intent is to transfer a significant share of the responsibility, accountability, and liability for completing the remediation effort to the vendor. For privatization to be implemented, the Department must be able to purchase identifiable, measurable deliverables (products) that can be shown to comply with well-defined technical specifications. The technical specifications for these products must evolve from, and be consistent with, the TWRS baseline requirements set.

Based upon the results of an early feasibility study, the approach to privatization will be conducted in two phases. The first phase will be a Proof-of-Concept/demonstration effort which would involve the pretreatment and vitrification of low-activity waste for approximately ten percent of the tank waste over a five year period. Three contractors will be selected to prepare detailed designs, from which two will be selected to actually construct, operate, and possibly decontaminate and decommission the facilities. The second phase will be a full-scale production phase. The facilities will be sized so that all of the remaining wastes can be processed and immobilized within the time allowed by the baseline schedule, while meeting environmental, health, and safety requirements, and realizing significant cost savings over the GOCO strategy.

A primary concern for the Department was how to configure a privatization program that will better satisfy the TWRS mission and still be consistent with the statutory requirements imposed on the existing TWRS baseline program. Figure 2 is a functional flow diagram, depicting the intermediate processing steps that the Hanford tank wastes must undergo, once they are removed from their present storage locations until safely disposed of underground. It also identifies those responsibilities that are expected to remain with the M&O contractor during the first, proof-of-concept phase and those that are expected to be transferred to the private vendors. Since the private vendors will only be paid for products that comply with pre-determined specifications, a key to the success of this new strategy is the preparation of specifications which will ensure that the requirements imposed on the overall TWRS Program will eventually be met.

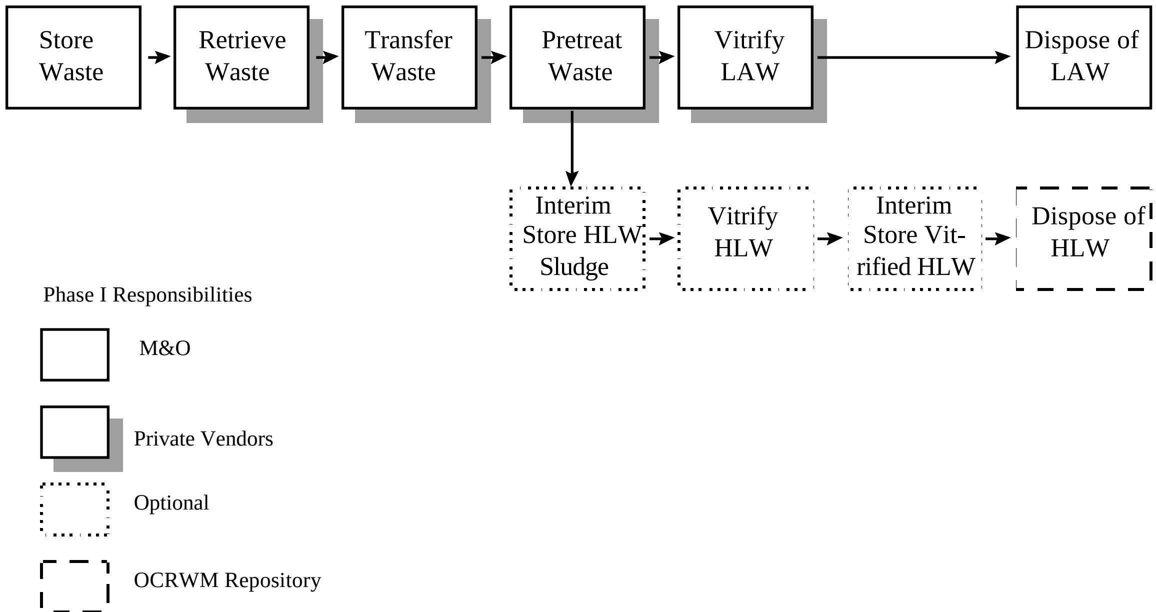

Figure 2. Tank Waste Remediation System - Functional Flow Diagram

To a certain extent some of the lower-level TWRS functions and their requirements are dependent upon particular strategies, chemical processes, or physical designs selected by the current GOCO contractor. Thus, the system functional decomposition required some modification such that private vendors would not be precluded from proposing any unique design solutions and the proposed division of responsibilities between the M&O and private vendors could be more easily accommodated. In particular, it was especially important to provide clearly defined interfaces between functions that would be performed in whole by the M&O contractor and functions that would be performed in whole by the private vendors. These interfaces and their corresponding requirements became the basis for preparing Interface Control Documents which will be used by the Department to ensure proper integration between the various contractors.

Phase one of the privatization effort is essentially a test or demonstration of the TWRS Program. Thus, the phase one requirements must be constructed in such a way as to verify the original set of TWRS requirements. Basically there are two types of requirements to consider: first, are those requirements which convey verbatim and apply regardless of how the products are produced, such as requirements on the long-term performance of the waste products; and second, are those requirements that need to be scaled down because of the reduced processing rates associated with a proof-of-concept demonstration. For example, whereas the full-scale requirement might specify an 8 metric ton/day production capacity, the proof-of-concept requirement may only call for 1 metric ton/day. Even though the ultimate production capacity would not be demonstrated, it would be much less of an extrapolation for a new, unproven process than from a laboratory bench test. The private vendors are being asked to comply with these test requirements (i.e., proof-of-concept requirements) instead of the corresponding set of TWRS performance requirements.

An important aspect of specifying these new proof-of-concept requirements is to ensure explicit traceability back to the original set of baseline requirements and to provide a defensible basis for their establishment. The existing TWRS database is large and unwieldy. In order to support the ambitious RFP schedule, the systems engineers needed a relatively simple tool that could aid in the development of a somewhat modified functional hierarchy, communicate with the existing TWRS database, and coordinate the overall systems engineering process.

Coordinating the TWRS Overall Systems Engineering Process

In order to coordinate the privatization effort with the existing TWRS systems engineering database, an automated systems engineering tool was needed with the following characteristics. First, the tool had to be compatible with other tools already in use for the development and maintenance of the existing, large TWRS database. Second, the computerized tool must support a human/machine readable specification language consisting of both structured text and graphical constructs. Third, the tool must provide extensive static and dynamic analysis of the evolving specifications/designs maintained in a common knowledge database and support automatic construction of project documents for review of those analyses. Fourth, the essential capabilities of the systems engineering tool had to be usable by "non-tool experts" with minimal training and be available on PCs running Windows.

The systems engineering support tool, CORE®, developed by Vitech Corporation, was selected based on it's ability to satisfy all four of the above criteria. The key privatization planning activities supported by CORE® were:

- Develop hierarchical structure models of the functions and the physical entities that make-up the Hanford site;
- Develop machine executable functional process-flow models to identify and analyze the tasks that must be accomplished (who does what to whom, in what order, and with what resources);
- Develop machine executable information models of the interfaces between tasks (i.e., Interface Control Documents); and
- Develop an issue/analysis tracking model to aid the decision making process.

The first task was to down-load the existing TWRS database, which was stored in RDD-100®, into the CORE® information repository using the CORE® "To/From RDD-100" built-in translator. The CORE® built-in translator was used periodically to exchange database changes.

Next, new privatization function hierarchies were developed and integrated into the existing Hanford organizational structure. Figure 3 shows an example of the major functional/organizational entities that make-up the Hanford site using the *built from* relationship. This "parts-list" (using the *built from* relationship to connect parent to children) was broken down into lower-level, more detailed parts, as required to completely understand the existing Hanford site operations. The "Support Organizations" entity was decomposed into two parts: the M&O Contractor and the Privatization Contractor(s).

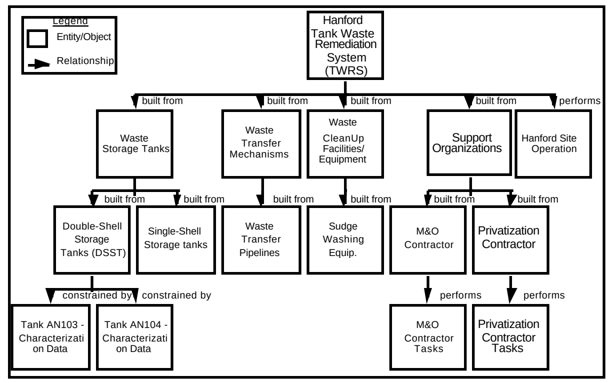

Figure 3. Hanford Functional/Organizational Entities Example

The required processes to be performed by the private vendors were developed using CORE®'s process-flow and data-flow modeling capabilities. A process-flow model consists of time precedence activity-nodes (i.e., function-nodes) and control-nodes which indicate concurrence (parallel processing), conditional branching, and sequential iteration loops. The data-flow (i.e., interfaces) associated with the activities represented in the process-flow model are shown using the N2 (N-squared) diagram technique (Figure 4). Together, the N2 diagram and its corresponding process-flow model increased understanding and improved communications among the team members with respect to the potentially complex interactions between functions.

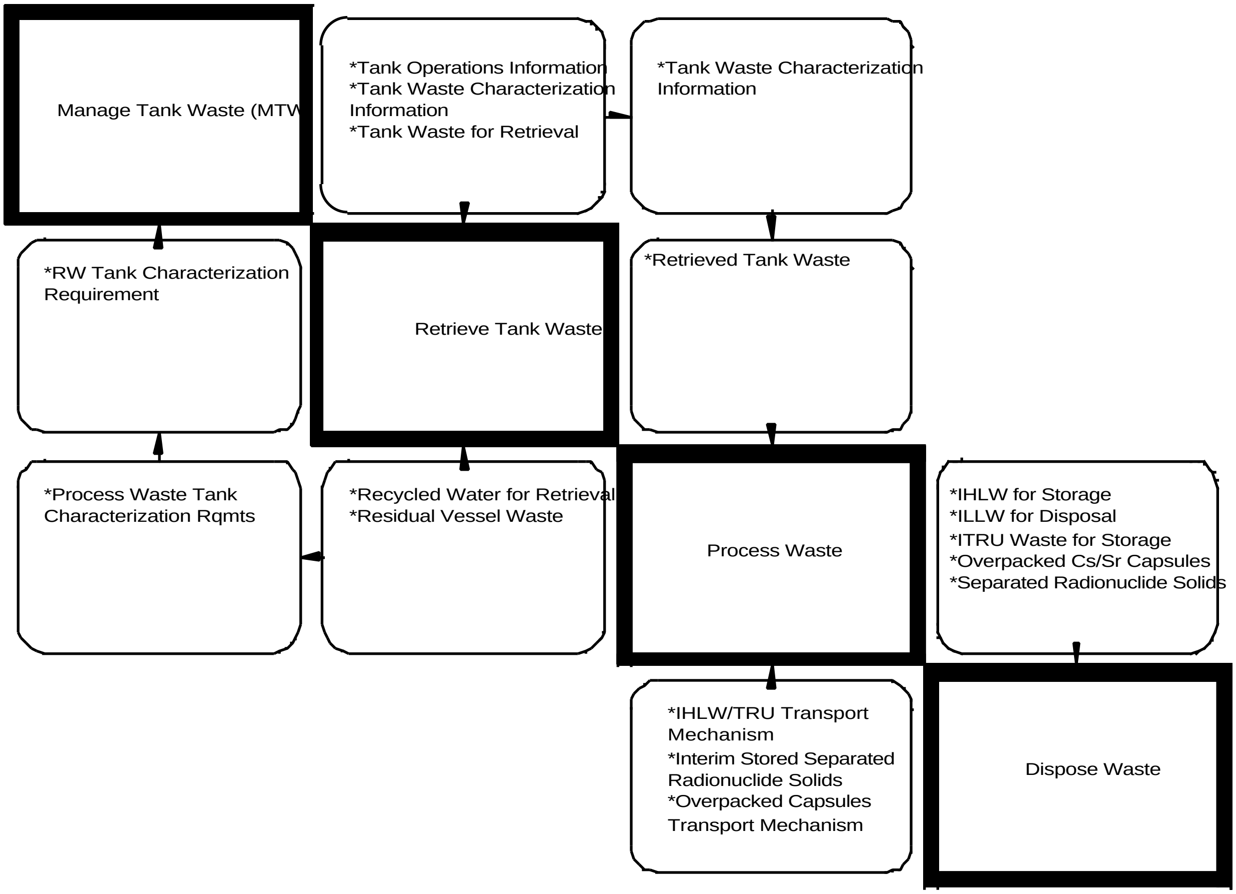

Figure 4. Hanford Site Operations Data-Flow Model Example

In addition to specifying the tasks and interfaces of the privatization effort, CORE®'s specification language was used to define a formal *issue identification, resolution, and tracking model*. This was especially important and useful, since much of the effort involved analyzing and verifying an existing, large database. Figure 5 shows the primary entity types (e.g., POCR, CriticalIssue, Risk, RequiredAnalysis, responsible Organization, and Source documents) and appropriate relationships used to associate one entity with another. The function to be accomplished during the proof-of-concept phase is the link between the two databases. Within the M&O's original program, a performance requirement specifies how well the function must be satisfied, whereas a proof-of-concept requirement (POCR) specifies how well the private vendors must satisfy the same function. The traceability schema illustrates the various analyses that must be conducted to provide proper documentation of the POCR and, thereby, eliminate any risks that may occur from the specification of an unsubstantiated requirement.

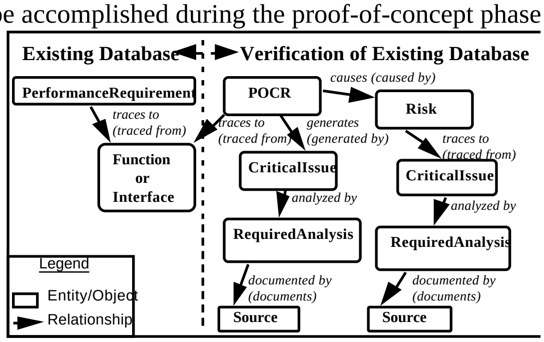

Figure 5. Traceability Schema between the Two Databases

An example of a COREâ -generated, human-readable form of this schema is shown in Figure 6 and the associated report is shown in Table 2.

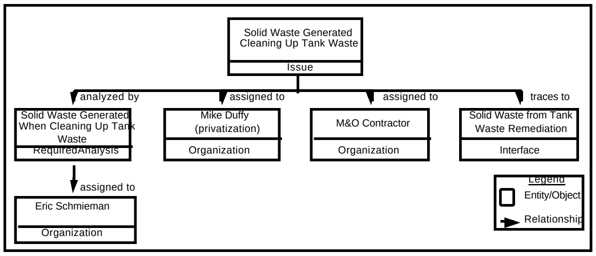

Figure 6. Issue & Analysis Tracking Database Content Example

Issue / Analysis Report

Solid Waste Generated Cleaning Up Tank Waste: A strategy for solid waste treatment needs to be selected to establish functions and interface requirements. The strategy may be some combination of treat/package at point of generation and treat/package at a central TWRS facility before transfer to site level Remedy Solid Waste function (4.3).

Issue Generated Because Of:

Interface: Solid Waste from Tank Waste Remediation

Due Date: November 28, 1995

Analyses:

An analysis is needed to identify the sources, composition, and volume of solid waste generated by TWRS facilities. An economic and feasibility analysis is required regarding when to employ central versus local liquid effluent processing.

Due Date: November 12, 1995

Assigned To: Eric Schmieman

Table 2. Example Issue/Analysis Tracking Report

Summary

The U.S. government is considering the privatization of a number of activities, ranging in scope from laundry services to multi-billion dollar environmental clean-up programs. In preparing a Request for Proposal (RFP) for privatizing all or part of an existing government operation, it is important to maintain consistency with the statutory requirements that have been imposed on the existing operation without precluding the possibility of new, innovative design solutions. Furthermore, if the operation to be privatized is large, complex, and potentially very expensive, it makes sense to begin the privatized effort with a smaller scale, proof-of-concept demonstration. In order to ensure that the demonstration program does, indeed, prove the validity of the overall concept, there must be documented traceability back to the full-scale requirements.

In the work at Hanford, the M&O contractor had invested a significant effort in developing an extensive systems engineering database. The privatization planning team, working with the M&O contractor, modified this existing database to support the issuance of an RFP for an initial proof-of-concept phase. Much of the effort was focused on the specification of new proof-of-concept requirements which would validate new waste processing technologies, guarantee the delivery of acceptable waste products, and ensure eventual compliance with the mandatory requirements of the original TWRS Program. A traceability schema was created, which, with the assistance of CORE®, was used to identify the need for new requirements, to specify required analyses necessary to substantiate the new requirements, and to provide the linkage back to the existing database. By implementing this approach, a consistent set of requirements was prepared that became the predecessor to technical specifications and Interface control Documents that are a part of the final RFP.

BIOGRAPHY

Dr. Michael Duffy holds a B.S. and an M.S. in Mechanical Engineering from Tufts University and MIT, respectively, a second M.S. in Engineering Management from Northeastern University, and a Ph.D. from Ohio State University. He has over 25 years of systems engineering experience in nuclear waste management, transportation, national defense, and space programs. Dr. Duffy is employed by Battelle Memorial Institute and recently completed a consulting assignment as the Chief Systems Engineer for the Department of Energy’s Tank Waste Remediation System (TWRS) Program at the Hanford Site in Washington.

Dr. William Sailor (Ph.D., University of California, Berkeley) has spent most of his career in nuclear and chemical engineering and nuclear physics at Los Alamos National Laboratory. He spent the last year contributing to the systems engineering effort for TWRS Privatization.

At the time this work was performed, **Eric Schmieman** was a Senior Research Engineer in the Systems Engineering & Risk management Department at Pacific Northwest National Laboratory. He is currently on educational leave of absence from Battelle while completing requirements for a Ph.D. in Environmental Engineering at Washington State University.

Loyd Baker, Jr. is a principal engineer for Vitech Corporation, the developer of the PC-based system engineering support tool COREâ. Mr. Baker performed a key technical role as senior consulting engineer at Accent Logic Corporation working with their RDD-100â engineering tool. At TRW, Mr. Baker managed the U.S. Army R&D program to develop the distributed computing design system (DCDS), a complete life-cycle system and software computer-aided development environment.